MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

ERT3036 – ADVANCED ROBOTICS

(RE)
(OPEN BOOK EXAMINATION)

1 MARCH 2019
3:00 p.m. – 5:00 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question paper consists of **6 pages** including cover page with **4 Questions** only.

2. Attempt **ALL** questions. The distribution of the marks for each question is given.

3. Please write all your answers clearly in the answer booklet provided.

Question 1

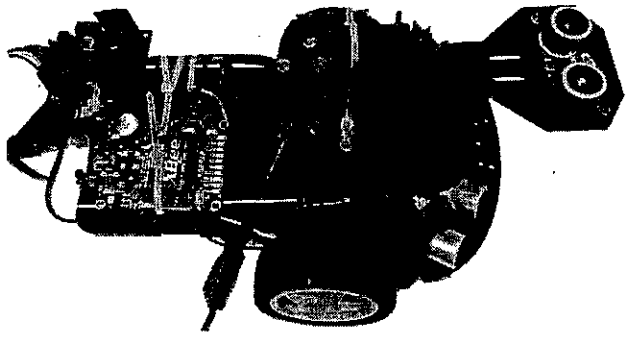


Figure Q1. A mobile robot for mapping

Figure Q1 shows a mobile robot for mapping designed by FET student. The following information is available for this robot.

Width of robot, $w = 0.2$m

Length of robot, $L = 0.5$m

Current position, $P = (1\text{m}, 3\text{m})$

Global position, $G = (5\text{m}, 1\text{m})$

Obstacle **1** position, $T1 = (3\text{m}, 2\text{m})$

Radius of $T1$, $R1 = 0.5$m

Obstacle **2** position, $T2 = (1\text{m}, 5\text{m})$

Radius of T2, $R2 = 0.6$m

Find the heading direction of this robot by using Artificial Potential Field **(APF)** method.

[25 Marks]

Continued ...

Question 2

Figure Q2 shows an exoskeleton that can help paralysed patient to walk again. The exoskeleton can be model as 4-link serial system as shown on the right.

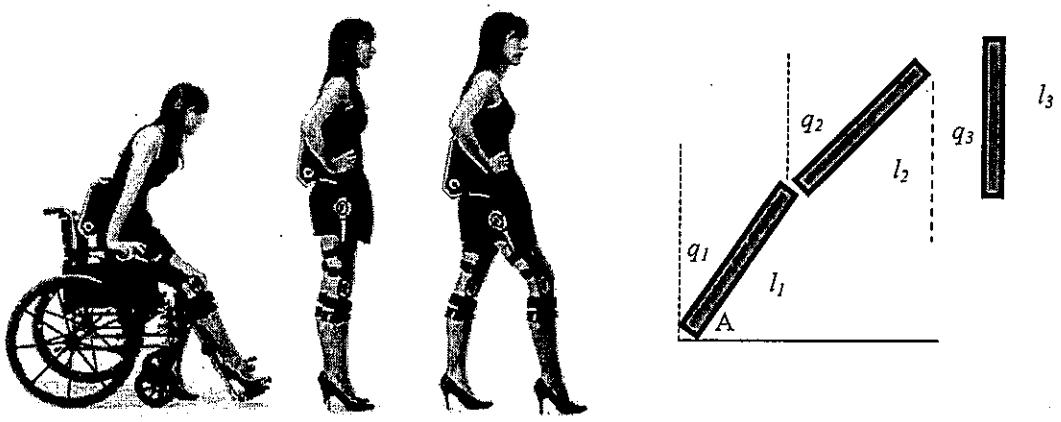


Figure Q2. A sequence of pictures showing exoskeleton at work and its model (Picture source: http://www.iwebstreet.com/rewalk-is-a-new-exoskeleton-that-lets-paralysed-people-walk-again/)

Let point A be located at (0,0) at the *x-z* plane (sagittal plane). Link 1 has a length of l_1 and mass of m_1 , link 2 has a length of l_2 and a mass of m_2 and link 3 has a length of l_3 and a mass of m_3. Link 4 is not shown on the model for simplicity.

The angles of link 1, link 2 and link 3 with respect to the vertical z-axis are q_1 , q_2 and q_3 respectively as shown in the model.

(a) Locate the coordinates for the centre of mass for link 3 (x_{c3} , z_{c3}).

[6 marks]

(b) Describe all possible sources of kinetic energy for link 3.

[2 marks]

(c) What is K_3 when the moment of inertial for link 3 is I_3?

[9 marks]

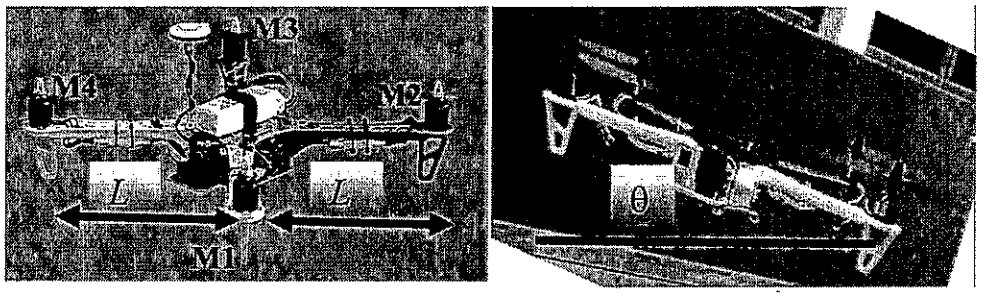
(d) Find $\frac{\partial K_3}{\partial \dot{q}}$.

[8 marks]

Continued ...

Question 3

A DJI F450 quadcopter is shown in **Figure Q3** with the mass, $M = 0.5$kg, $k = 6\text{x}10^{-8}$ N/ (rpm) ^{2} and $g = 9.81$ m/s^2.



(i) **(ii)**

Figure Q3. (i) The quadrotor is hovering. **(ii)** The quadrotor is moving to the right

(Picture Source: http://www.rcgroups.com/forums/showthread.php?t=1901564)

(a) When all four motors are rotating at same speed, ω , the quadrotor is hovering. Find ω in rpm.

[5 marks]

(b) When the quadrotor is making an angle θ with the horizontal plane, it moves along the x-axis to the right as shown. If the gravity force is still compensated with all the rotors are having the same speed at ω_m, and the acceleration in the x direction, $a_x = 2\text{m/s}^2$, find the angle θ and ω_m.

[8 marks]

(c) Briefly describe how you can change from hovering to moving to the right for this quadrotor.

[5 marks]

(d) When $T_1 = T_2 + \Delta T$, $T_2 = T_4$ *and* $T_3 = T_2 - \Delta T$, how much time is required to reach the desired tilt angle as in **(b)** when the moment of inertia for the quadrotor is $J = 0.0025$ kgm^2, $L = 0.225$m and $\Delta T = 5.07\text{x}10^{-4}$ N?

[7 marks]

Continued ...

Question 4

(a) **(i)** Kismet is a sociable robot created by Professor Cynthia Breazeal from MIT's Media Lab. It can display emotional states through facial expressions. Describe how this was done using the 3 dimensions of its affection states.

[4 marks]

(ii) Give a brief technical description for Pepper robot and Buddy robot robots as shown in **Figure Q4 (a)**.

[9 marks]

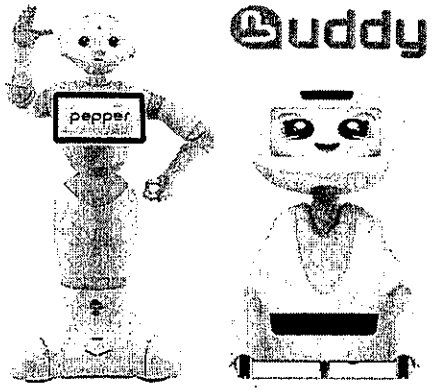


Figure Q4 (a). Pepper Robot and Buddy Robot

(b) **(i)** The parallel arm known as Adept Quattro Parallel Robotic Arm for high speed packaging and material handling tasks is shown in **Figure Q4(b).** List down 3 of its major specifications and describe the advantages of this arm for pick and place operation?

[6 marks]

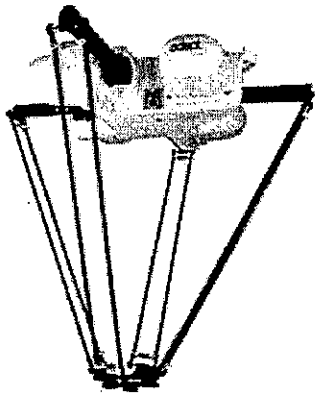


Figure Q4(b). A robot manipulator
(Source: http://www.directindustry.com/prod/adept-technology/parallel-robots-6076-568274.html)

Continued ...

(ii) The Q table for a Q-learning robotic system is shown in **Table Q4 (b)**. At this point of time, the learning rate, $\alpha = 0.3$, and the discount rate, $\gamma = 0.2$. All transitions have reward R = 0 except transition from B to D with a reward, R = 20 and transition from D to D with a reward of R = 30. Transition from A to B, Q(A,B), is 10 at the moment.

Find the final Q values for the transitions in sequence of From **A to B**, **B to D** and **D to D**.

[6 marks]

Table Q4 (b). Q Table

Source \ Final	A	B	C	D
A	0	10	4	2
B	5	2	0	7
C	2	2	1	3
D	1	3	0	2

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